contaminated large open wounds—benefit from immediate irrigation of the site with sterile saline (either poured from a bottle or administered with a pulsatile irrigation system) and removal of any gross debris. A compressive dressing should then be applied; this can be soaked in a dilute solution of Povidine if formal surgical debridement will be delayed. The fracture should be reduced, if possible, and then immobilized in a long-leg, well-padded splint. Intravenous antibiotics should be administered as soon as possible. One gram of Cefazolin intravenously every 8 hours suffices for most open fractures. Penicillin and an aminoglycoside may be necessary as well in highly contaminated fractures—particularly those that occurred in an agricultural setting, where there is a high risk of clostridial infection. A careful assessment of neurovascular function is essential. Because compartment syndrome can occur in open fractures, this assessment includes an essential search for compartment syndrome and measurement of compartment pressures (if indicated). The patient should be taken to surgery as soon as possible, where a meticulous layer-by-layer debridement and pulsatile irrigation must be accomplished. It is safest to leave the wounds open and perform delayed primary closure. There is evidence to suggest the utility of implanting polymethylmethacrylate beads that are impregnated with antibiotics and covered with an oxygen permeable membrane. Doing so may reduce the infection rate and protect tissues sensitive to dehydration.

The fracture immobilization method of choice involves inserting an unreamed locked intramedullary nail. Gently using one or two reamers to enable the placement of a larger nail with stronger cross-locking screws is also acceptable. In fracture patterns where intramedullary nailing is not practical, external fixation is the appropriate treatment

As soon as the wound is free of necrotic tissue and any evidence of infection, closure should be performed—with local or free full-thickness flaps if necessary. In cases of severe open fractures, delayed union or nonunion of the fracture is common. In cases in which there has been extensive soft tissue stripping or bone loss, early grafting with autologous cancellous bone may hasten the rate of union and reduce the incidence of a nonunion. This grafting is usually performed after the soft tissue envelope has recovered from the injury, between 6 and 12 weeks after the injury. Using current techniques, acute infection rates vary from 3% to 7%, with union rates of 98% to 100%. Recent studies have shown that late osteomyelitis rates continue to approach zero.

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REFERENCES

Tomena P III, Bergman M, Watnik N, Berkowitz G, Steuer J. Treatment of grade III-B open tibial fractures. J Bone Joint Surg 1994. 76B13

Lumbar Interbody Fusion Utilizing Fusion Cages

LOW BACK PAIN is the most common musculoskeletal complaint reported to physicians by their patients. At one time or another, 95% of the general population will experience significant low back pain. Fortunately, 95% of these patients improve within three months of presentation. The majority of the dollars used to treat low back pain is spent on the remaining 5%. Low back pain remains the largest source of disability in the working population.

Despite its pervasiveness and significant sociological impact, identifying the source of low back pain remains elusive. In fact, of those patients presenting with low back pain, only 15% will be accurately diagnosed. Many authors believe that the source of the pain is the disc itself. The disc can either undergo painful degeneration or become acutely injured. Injury to the disc itself is commonly referred to as internal disc disruption.

In patients who remain symptomatic despite an aggressive conservative care program, surgical treatment may become an option. Many spinal surgeons advocate lumbar fusion for the treatment of unremitting low back pain that has been refractory to aggressive conservative care. Many fusion techniques (posterior, posterolateral, or interbody) and approaches (anterior, posterior, or both) are available.

Many believe that interbody fusion (fusion between the vertebral bodies) offers a number of advantages to posterior interlaminar or posterolateral intertransverse process fusion. The cancellous bone of the vertebral body provides an excellent fusion bed, as opposed to the surgically traumatized posterior paraspinal musculature. Interbody fusion allows the disc space to be both evacuated and distracted. Distraction allows the neural foramen to be enlarged, eliminating any foraminal stenosis that might be present secondary to degenerative loss of disc height. Interbody fusion can be accomplished by either an anterior or a posterior approach. Autografts or allografts can be a number of shapes (dowels, blocks, rings, or chips).

In an attempt to improve stability, expedite the rate of fusions and recovery, and improve patient function, interbody devices have been developed. The precursor to these implants was the "Bagby Basket," designed to treat a form of cervical instability known as "Wobbler Syndrome" in horses; this technology was modified for human use in the mid-1980s. These devices consist of threaded, perforated titanium cylinders. Another device currently in clinical trials is a carbon fiber rectangular cage. This cage is packed with bone graft and inserted between the vertebral bodies through either an anterior or a posterior approach. The anterior approach can be either retroperitoneal or laparoscopic. The laparoscopic approach can be quite challenging at the L4–5 level because of the overlying vascular structures, but quite feasible at the L5–S1 level.

The rate of fusion with the use of the threaded titanium cages is encouraging and is comparable to either posterior or combined anterior and posterior fusion. In addition, interbody fusion is between 30% and 40% less costly than combined anterior and posterior fusion. The device-related complication rate is quite low, particularly when the device is implanted anteriorly. Clinical trials are underway to evaluate the use of fusion cages in the thoracic and cervical spine.

This technology represents a significant step forward in the treatment of low back pain. It is important to recognize, however, that the surgical indications for lumbar spine fusion for low back pain remain unchanged and that the goal is not only a solid fusion but a more functional patient.

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REFERENCES

Hacker RJ. Comparison of interbody fusion approaches for disabling low back pain. Spine 1997; 22:660–665

Ray CD. Threaded fusion cages for lumbar interbody fusions. Spine 1997; 22:667–669

Ray CD. Threaded fusion cages for lumbar interbody fusions: an economic comparison with 360-degree fusions. Spine 1997; 22:681–685

Pelvic Fractures

PELVIC FRACTURES WITH their associated injuries can produce significant short-term mortality, with rates of 10% to 20%. When head injury accompanies a pelvic fracture, the mortality rate can climb to 50%. Pelvic injuries also have significant long-term morbidity, such as late pain and the impaired function of the pelvis for sitting and weight bearing that results from pelvic nonunion, pelvic malunion, and leg-length discrepancy. Current methods to reduce the high mortality and morbidity rates begin with the emergency resuscitation phase and continue into the definitive treatment phase. In the past, nonoperative treatment was often considered the safest option; today, however, with our improved techniques and medical care, operative treatment can lead to reduced morbidity.

An important concept is that *both* anterior and posterior injuries occur in pelvic injuries (with only rare exceptions). Some long-term morbidity is related to the failure to recognize an unstable posterior injury. Frequent use of CT scanning has assisted in locating posterior injuries, but the assessment of pelvic stability can still require the expertise of a traumatologist who frequently treats these injuries. A stable pelvis is one that is able to withstand normal physiologic forces without abnormal deformation, which is determined by the remaining intact bony and ligamentous structures after injury. Radiographic signs of instability include symphysis diastasis more than 2.5 cm; ischial spine or lateral sacrum avulsion fractures; L5 transverse process fractures; sacroiliac translation more than 1 cm; and a sacral fracture gap instead of impaction. When the injury results from high-energy mechanisms—such as motor vehicle accidents or falls from great heights—a high index of suspicion for instability is necessary to avoid complications related to inadequate treatment. When instability is suspected but not obvious, push/pull stress x-ray studies or fluoroscopy can confirm excessive motion at the posterior injury site.

When the mechanism of injury is considered, the pelvis is believed to respond to three primary forces of injury: external rotation, lateral compression, and vertical shear. Each of these forces, depending on the energy of the injury, can lead to stable injuries, to severely unstable injuries, or to injuries that fall anywhere between these categories. Combined forces of injury lead to combined patterns of injury, which also makes the evaluation of specific injuries more difficult.

Pelvic injuries resulting from low-energy mechanisms, such as avulsion fractures or low-height falls in older patients, are generally stable and usually treated symptomatically, whereas pelvic injuries resulting from high-energy trauma are treated according to ATLS protocol. The methods to address major intrapelvic bleeding include orthopedic reduction and stabilization of the pelvic ring; angiographic embolization; and open surgical repair, ligation, or packing. Reducing and stabilizing the pelvic ring with emergent external fixation decreases intrapelvic volume (assisting tamponade), minimizes motion at the fracture site, and assists patient mobility and transport during resuscitation and evaluation.

Angiography localizes bleeding and allows for therapeutic embolization, which can lead to excellent hemodynamic control. Whether external fixation or angiography is done first remains controversial. Either is indicated for persistent hypovolemic shock after fluid and blood replacement. Open surgical repair, ligation, or packing is primarily reserved for patients who do not respond to external fixation and angiographic embolization, and for those who have injuries to large vessels such as the external iliac or common iliac artery.

The orthopedic goal in an emergency setting is common to all physicians: to assist with patient resuscitation. When the patient requires emergency surgery for abdominal bleeding, genitourinary or gastrointestinal injury, or other reasons, the orthopedic surgeon should be involved early to ensure the consideration of emergent stabilization with external fixation, open reduction and internal fixation, and even percutaneous iliosacral screws. When communication is strong among surgical subspecialties, many of these options can be done expeditiously and in conjunction with other procedures. For example, midline abdominal incisions can be quickly extended to the symphysis for plate stabilization of symphyseal injuries.

External fixation can be performed quickly by experienced surgeons and with particular attention to positioning away from the abdomen, if a laporotomy incision is planned. Additional pins and bars or adjustments can be made after the initial resuscitation. When external fixa-